

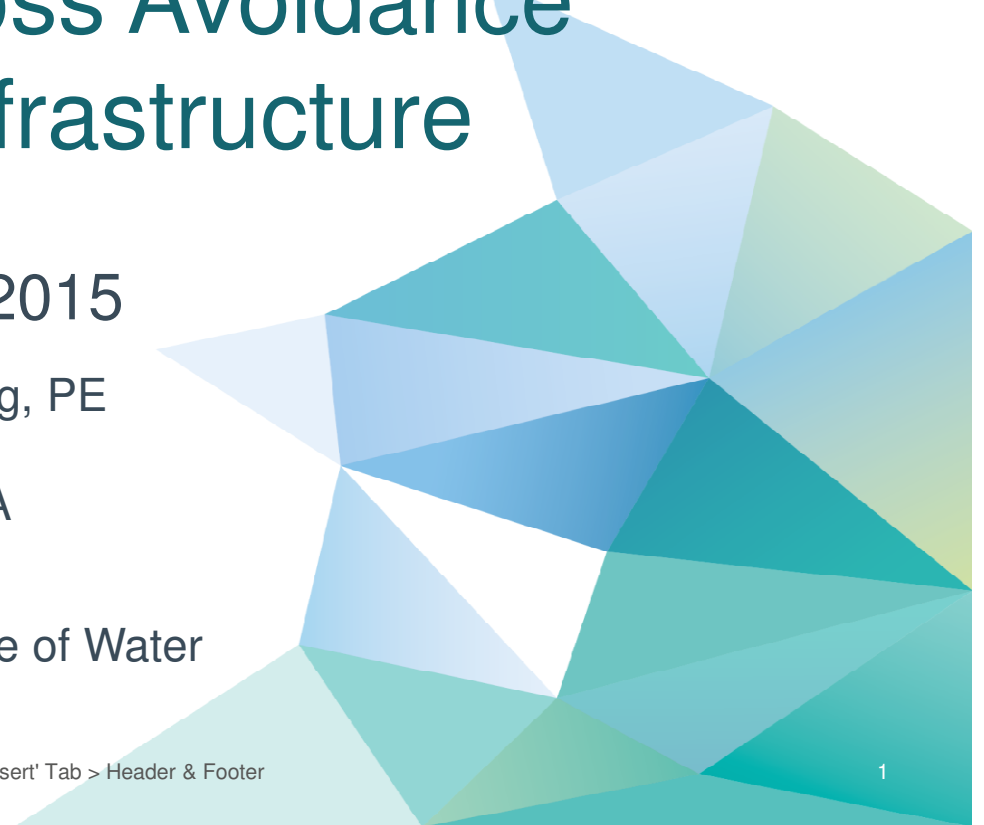
Nationwide Flood Loss Avoidance Benefits of Green Infrastructure

FMA Conference, September 2015

Dan Medina, PhD, PE
Atkins
Washington, DC

Leo Kreymborg, PE
Atkins
San Diego, CA

Lisa Hair, PE
US Environmental Protection Agency, Office of Water
Washington, DC



Background

Objective: Estimate flood losses avoided by nationwide implementation of GI for new development and redevelopment

Features:

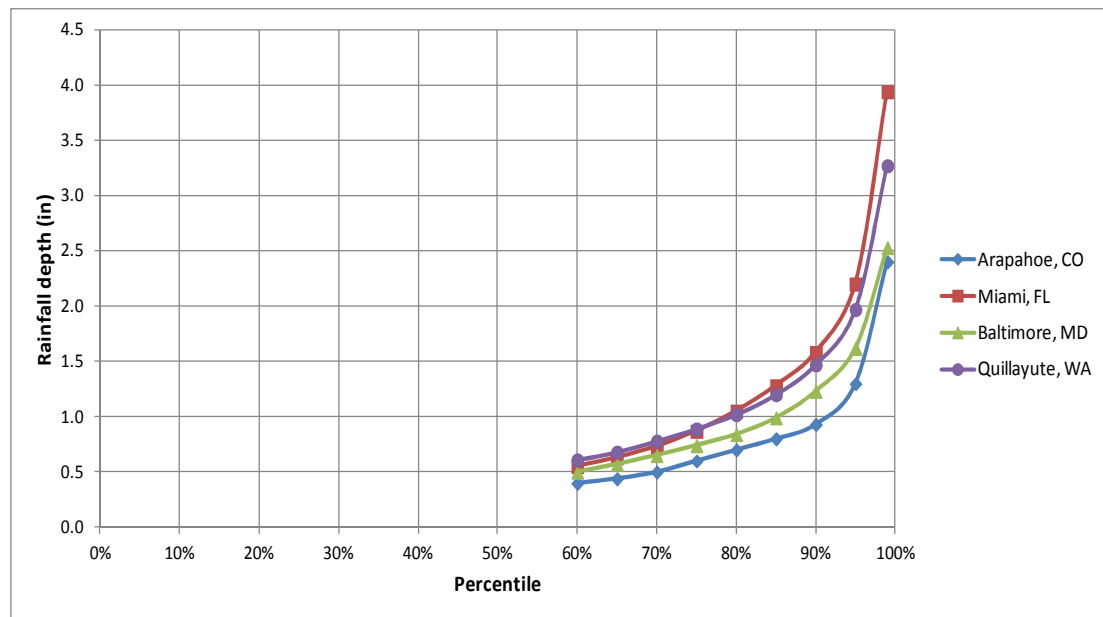
- Capture and retain on site a high percentile storm
- Example capture standard:
 - 90th percentile for new development
 - 85th percentile for redevelopment
- Assumed to start in 2020; snapshot at 2040

Not proposing GI for flood control; these are side benefits to water quality benefits



Retention Standard Definition

- X^{th} percentile storm: The event whose precipitation depth is greater than or equal to $X\%$ of all storm events over a given period of record
- The retained volume must be infiltrated, evapotranspired, or harvested for beneficial use



Study Plan

Rationale: smaller runoff volume leads to smaller floodplains and thus fewer flood damages

- Evaluate 20 HUC8 watersheds with and without GI-based retention
- Estimate monetary flood losses for each scenario
- Benefits = losses without GI – losses with GI
- Scale results nationwide



Sample Watersheds

ATKINS



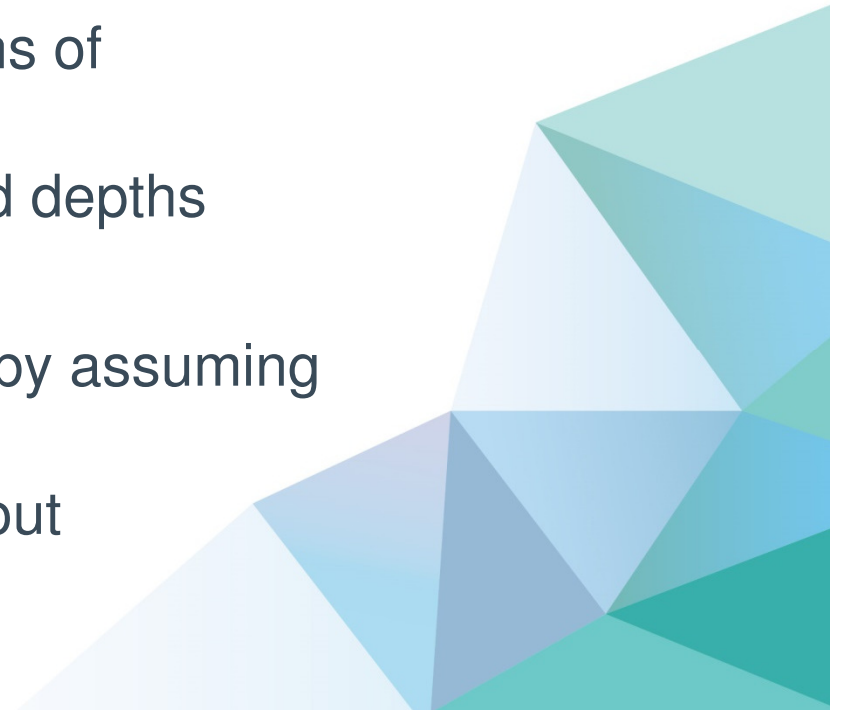
Datasets

- USGS streamflow records
- USGS National Elevation Dataset (NED) (10-meter)
- National Land Cover Dataset (NLCD)
- STATSGO2 soil types
- Census 2000 economic activity
- ICLUS economic growth projections



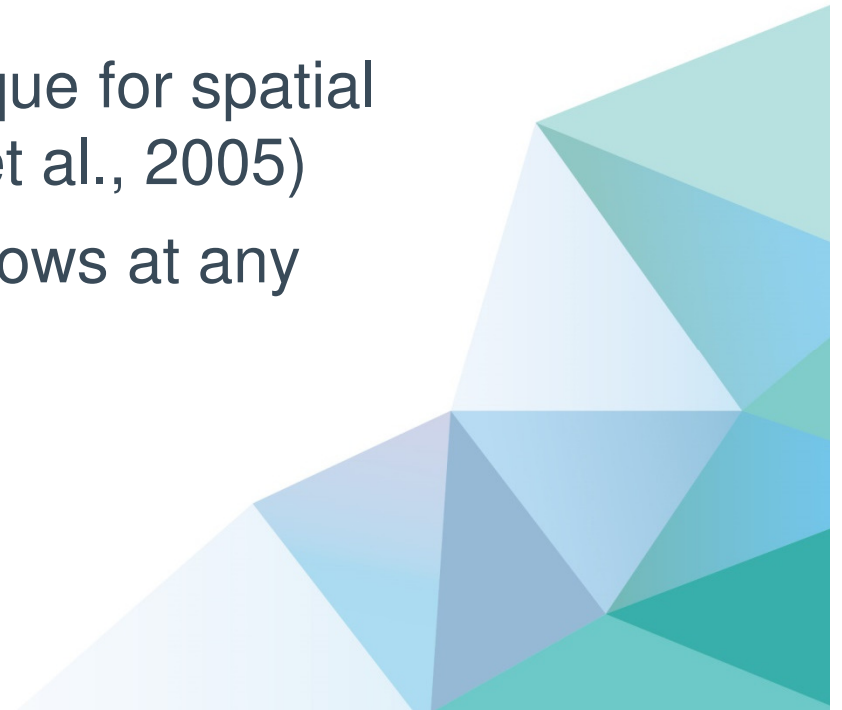
Procedure

1. Estimate current peak flow distribution from USGS gage data
2. Adjust peak flows to 2040 projections of impermeability without GI
3. Hydraulic modeling to estimate flood depths
4. Calculate damages in HAZUS
5. Repeat step 1-4 but reduce runoffs by assuming GI implemented.
6. Damages avoided = Damages without GI – Damages with GI



Hydrology

- Flood frequency analysis with USGS's PeakFQ software
- Region of Influence (ROI) technique for spatial interpolation of peak flows (Eng et al., 2005)
- Obtain existing conditions peak flows at any location



Estimation of Future Hydrology

- Use runoff volume ratios to adjust peak flows (Milwaukee Metropolitan Sewer District, 2005)
- Runoff volume from TR-55 methodology
- Future conditions (2040), no GI

$$Q_{2040} = Q_e \frac{V_{2040}}{V_e}$$

- Future conditions, with GI

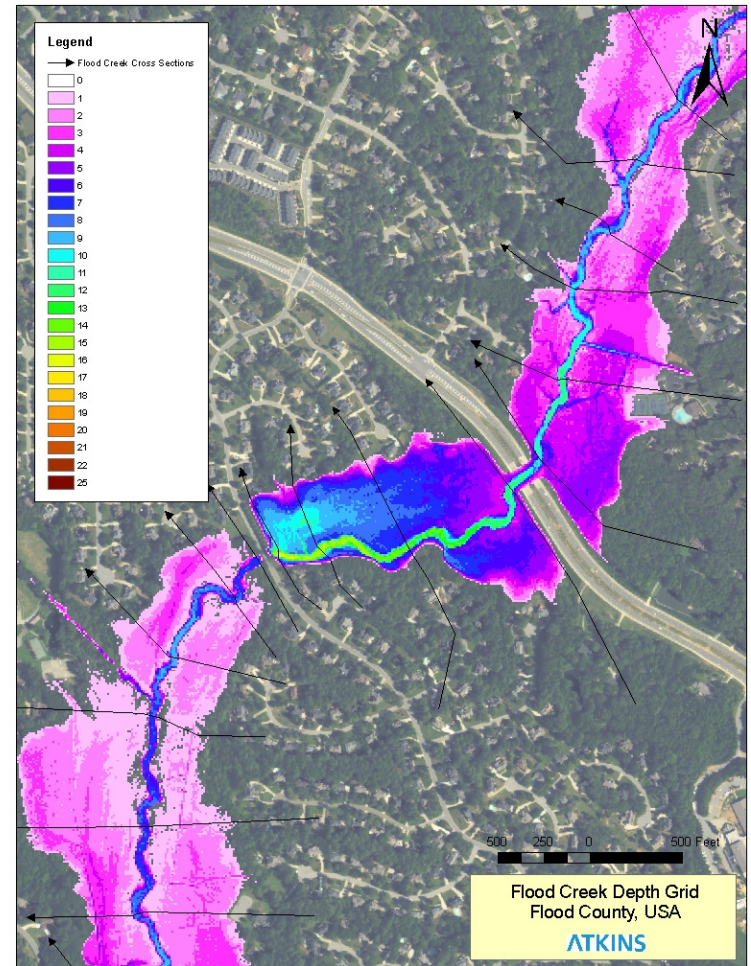
$$Q_{GI} = Q_e \frac{V_{GI}}{V_e}$$

$$V_{GI} = V_{2040} - d_{80}$$

Example: d_{80} = 80th percentile depth

Hydraulic Modeling

- Rapid Flood Delineation (RFD) model
- High speed hydraulic profile calculation
(1,000 miles per hour)
- Mostly automatic cross sections
- Depth grids



Source: 2009 NADP Orthophoto

Flood Damage Estimation

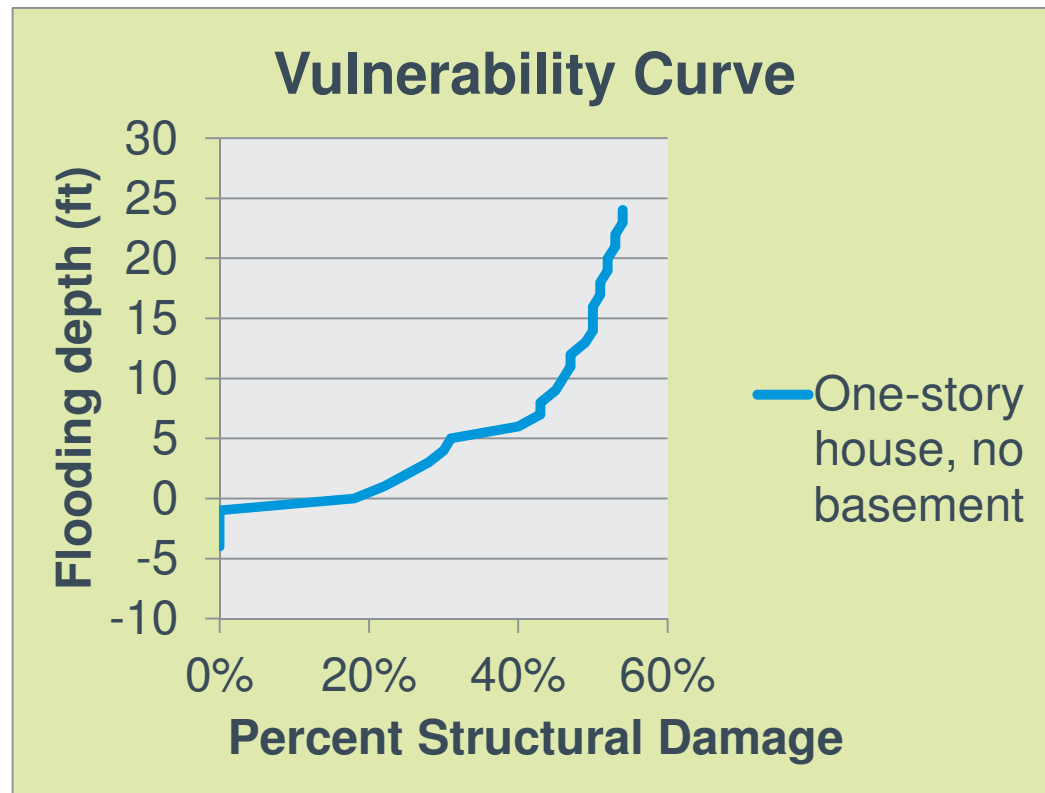
- FEMA's methodology for estimating potential losses from disasters
- GIS-based



ATKINS

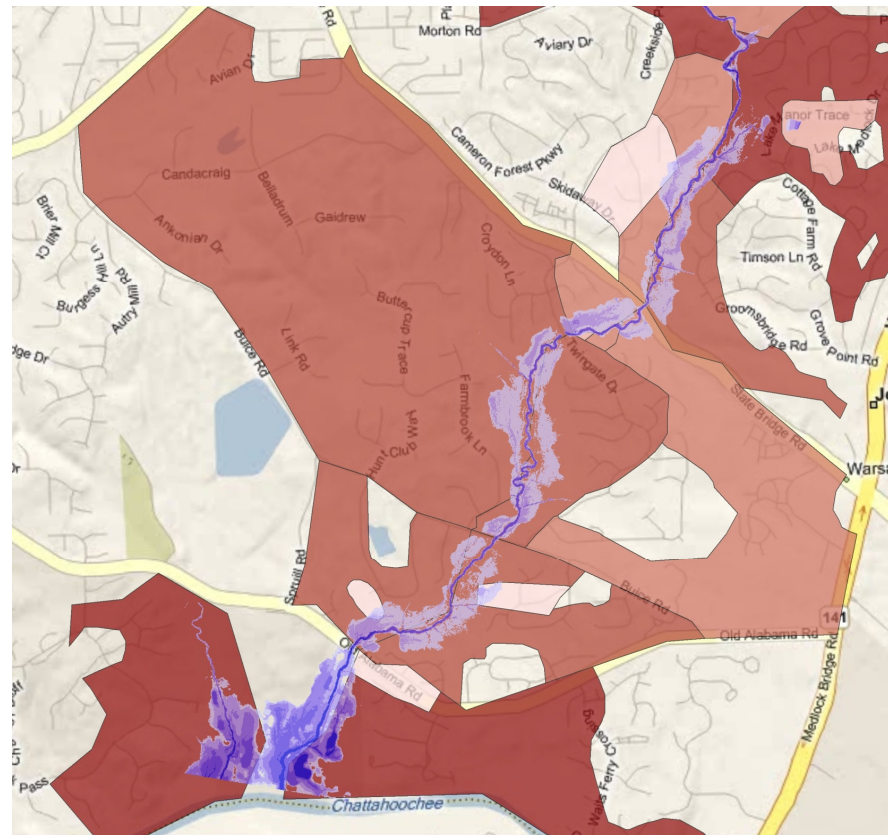
Vulnerability Curves

- Federal Insurance Administration (FIA) curves
- USACE curves

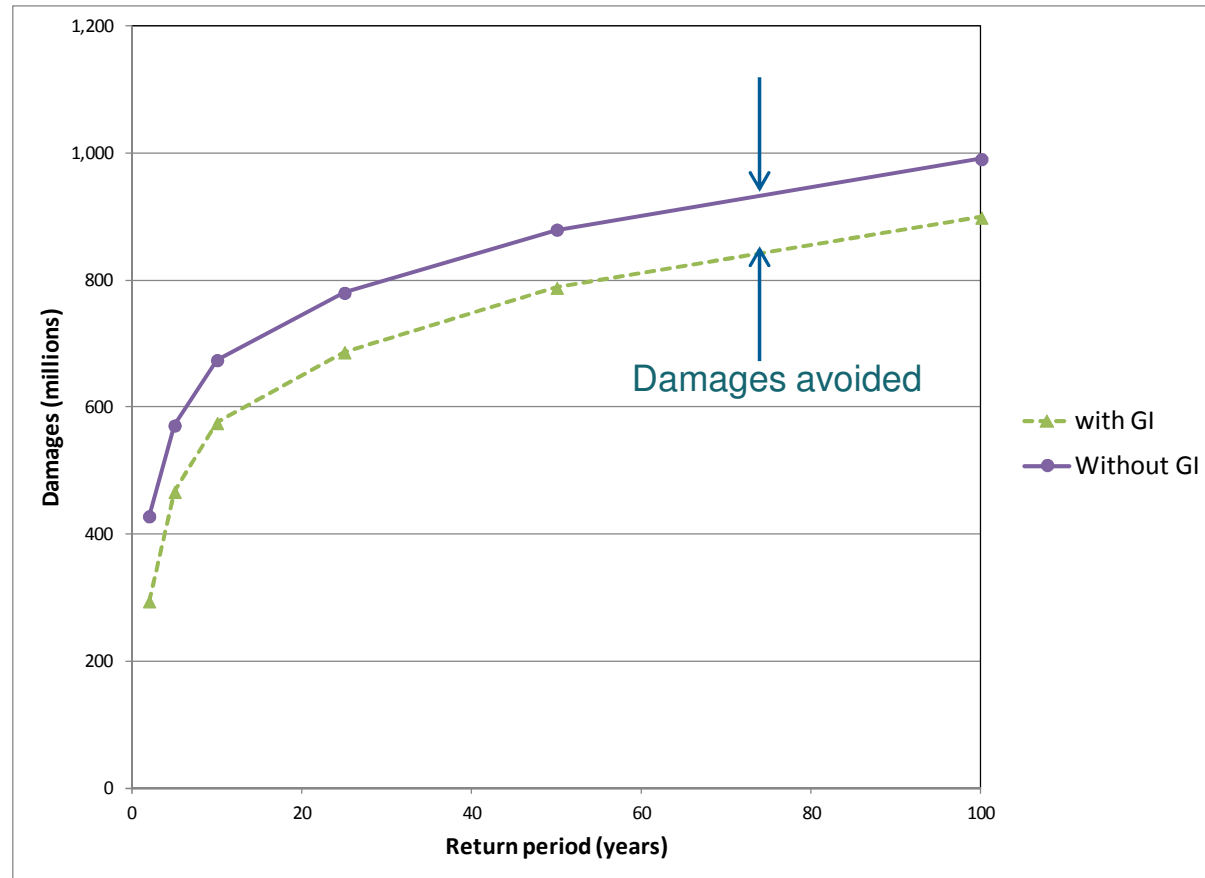


Flood Damage Computation

- Hazus uses General Building Stock (GBS)
- Assumes uniformly distributed assets on Census blocks



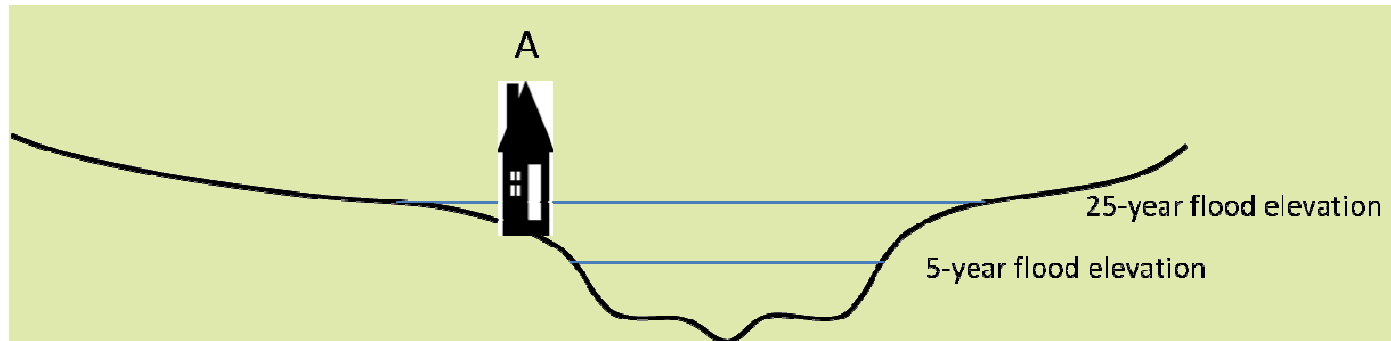
Flood Losses Avoided



Zero-damage Threshold

Damages begin to occur when:

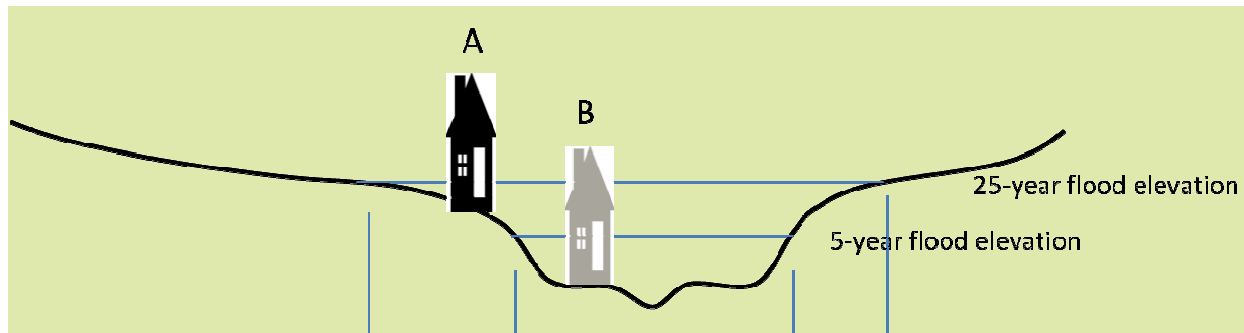
- Flood waters enter the floodplain, and
- Water reaches exposed assets



Zero-damage Threshold

GBS uniform distribution of assets on Census blocks:

- Some assets appear at risk when they are not
- Damages can be overestimated

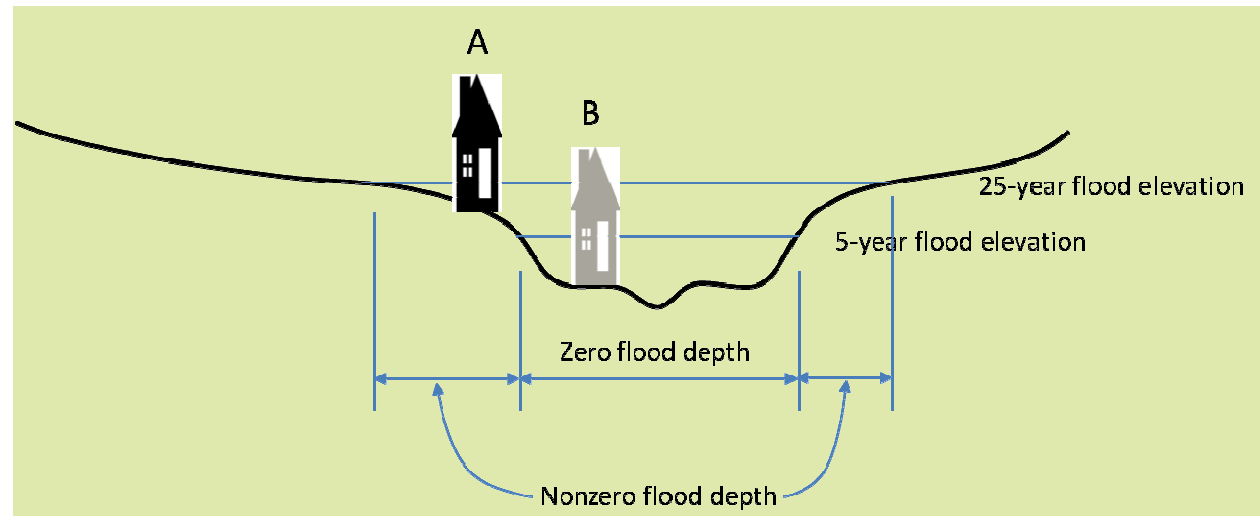


Zero-damage Threshold

Flood event at which damages begin to occur

1. No assets exist in the 2-year floodplain
2. No assets exist in the 5-year floodplain
3. No assets exist in the 10-year floodplain

} thresholds

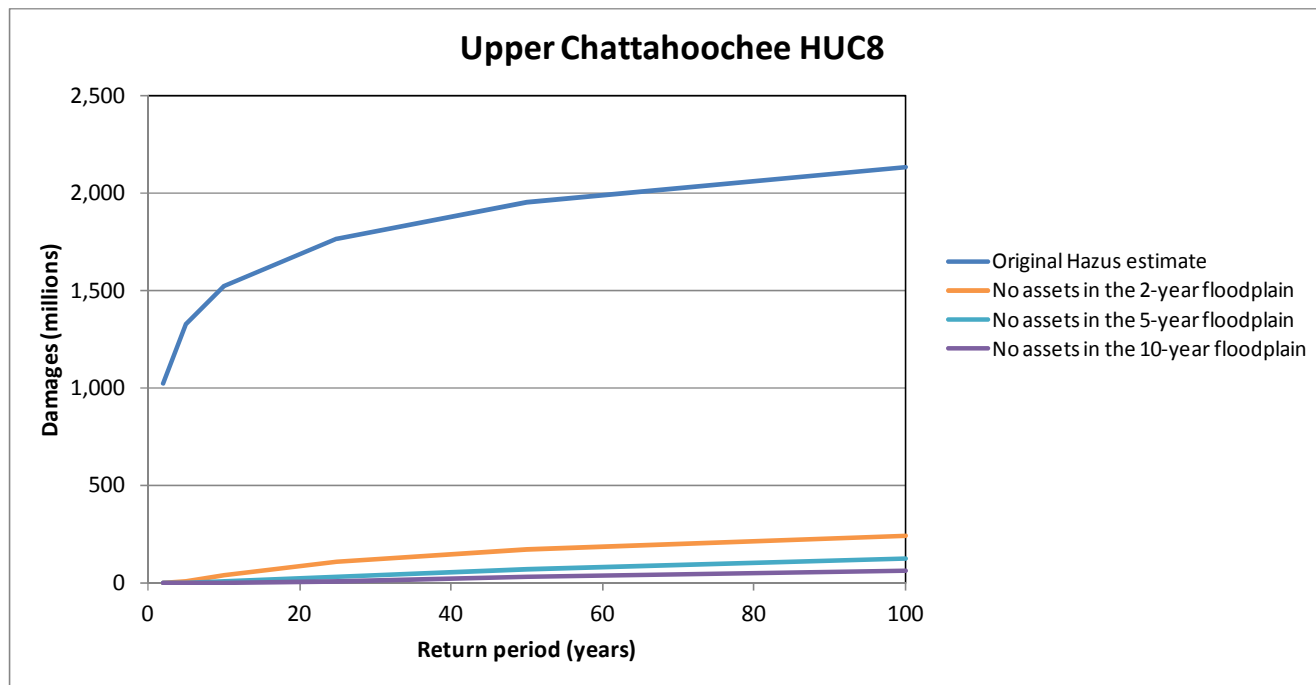


Zero-damage Threshold



Distribution of Avoided Losses

Year 2040 development (2011 dollars)





Event without GI

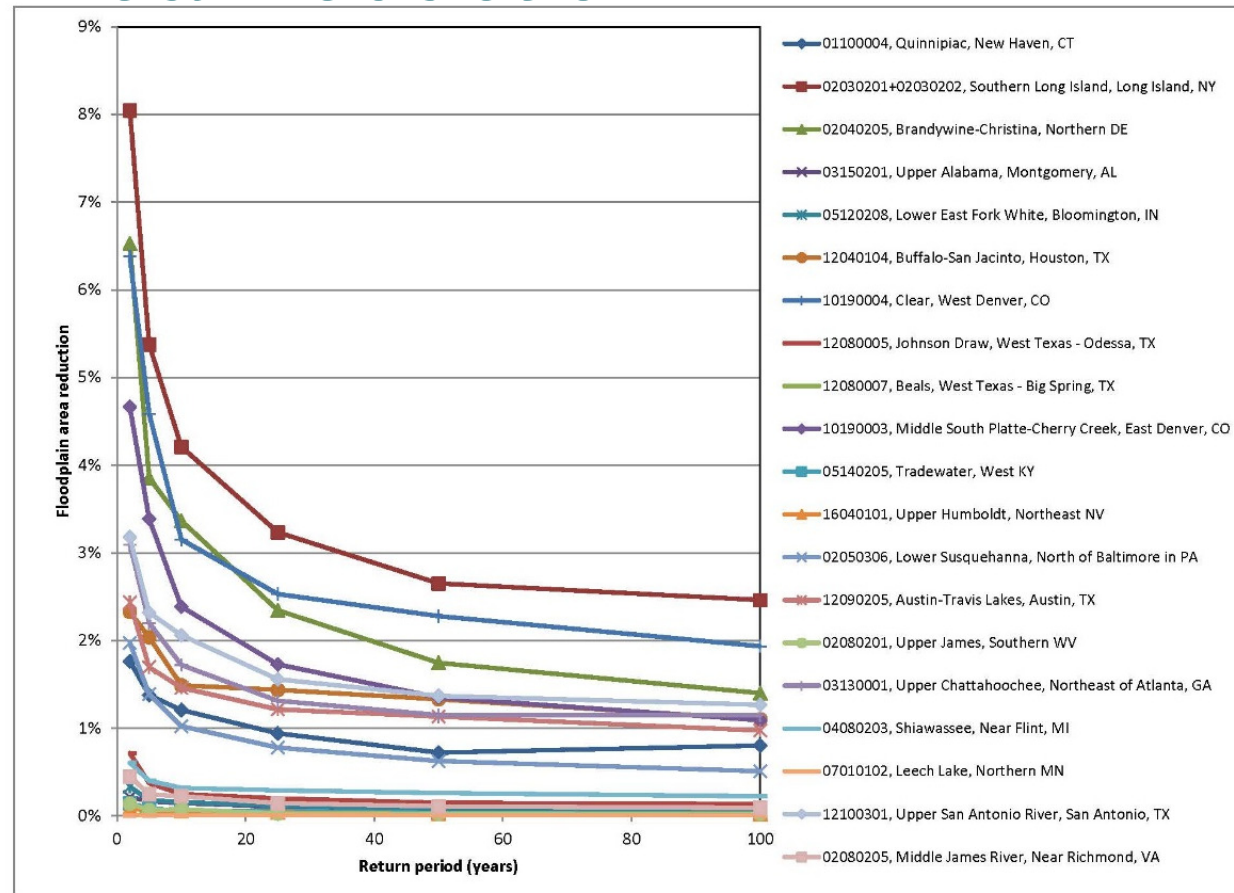
ATKINS



Event with GI

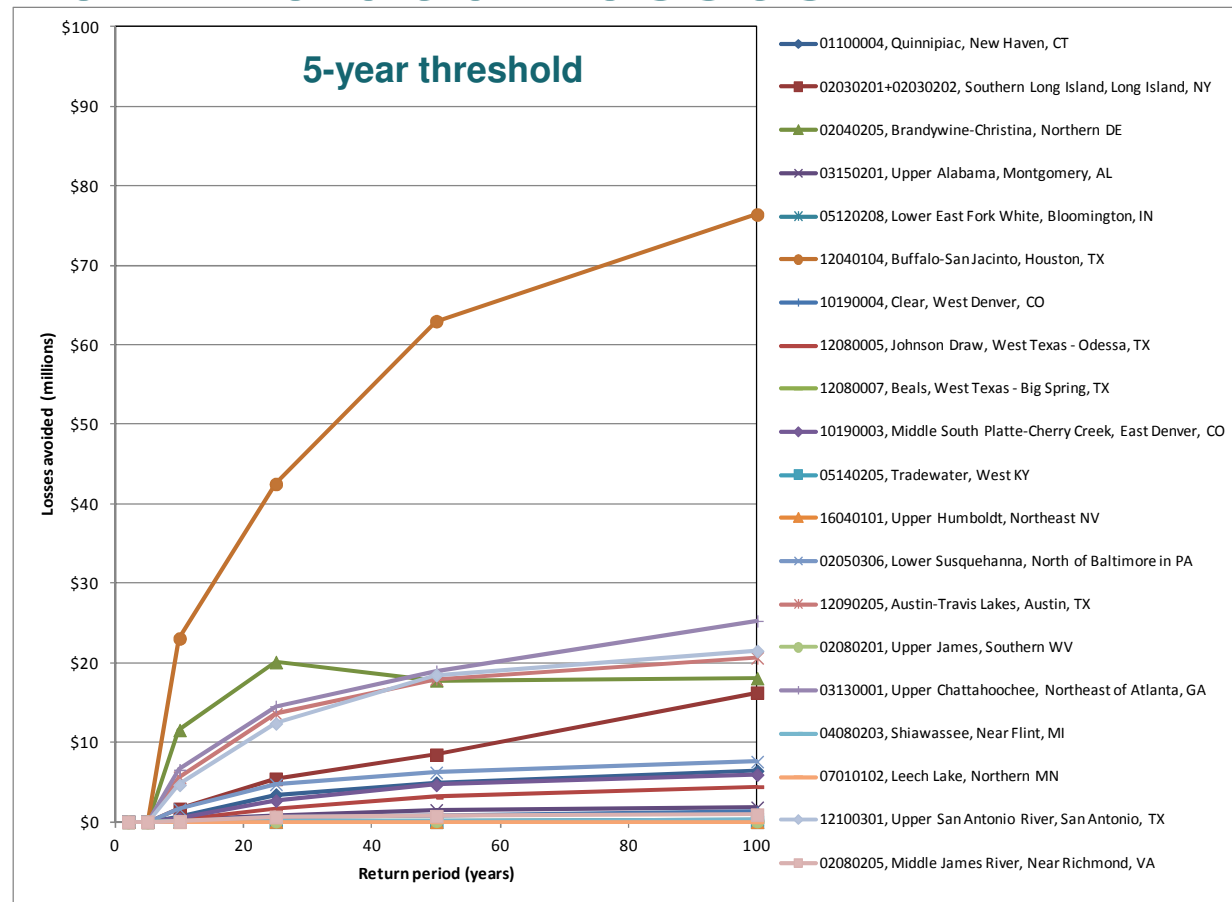
ATKINS

Floodplain Area Reduction



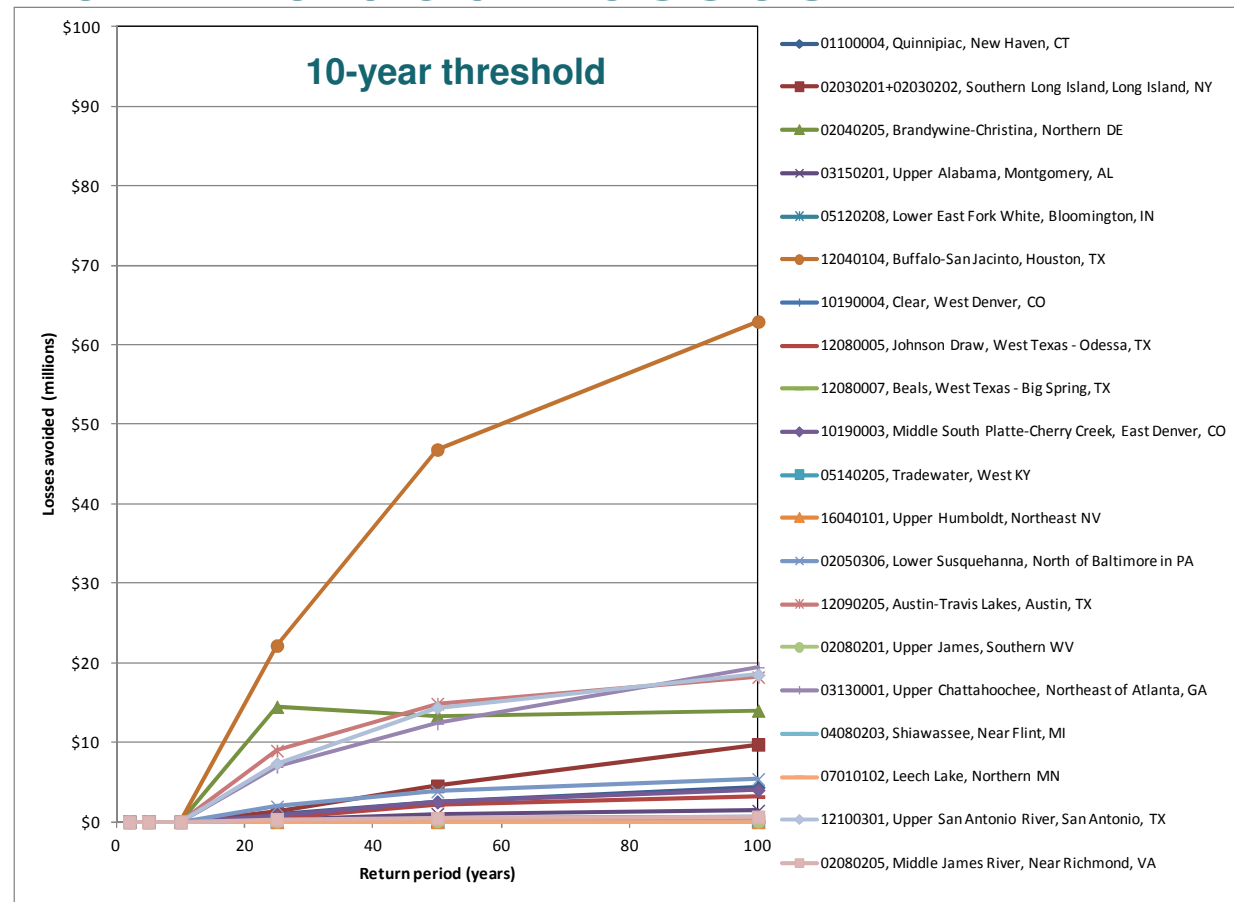
Distribution of Avoided Losses

Year 2040
development
(2011 dollars)



Distribution of Avoided Losses

Year 2040
development
(2011 dollars)



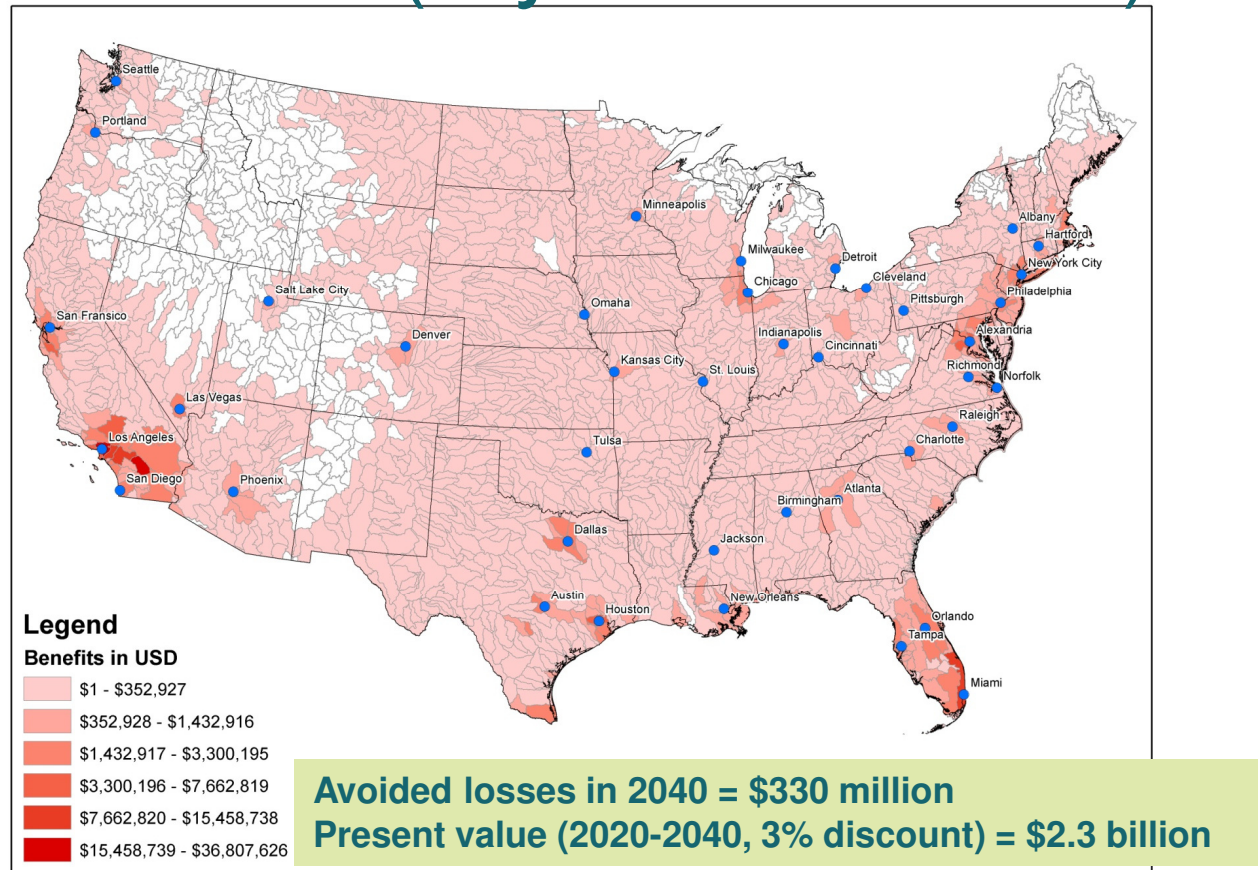
Nationwide Scale-up

Regressed Watershed properties vs. avoided losses as fraction of total assets

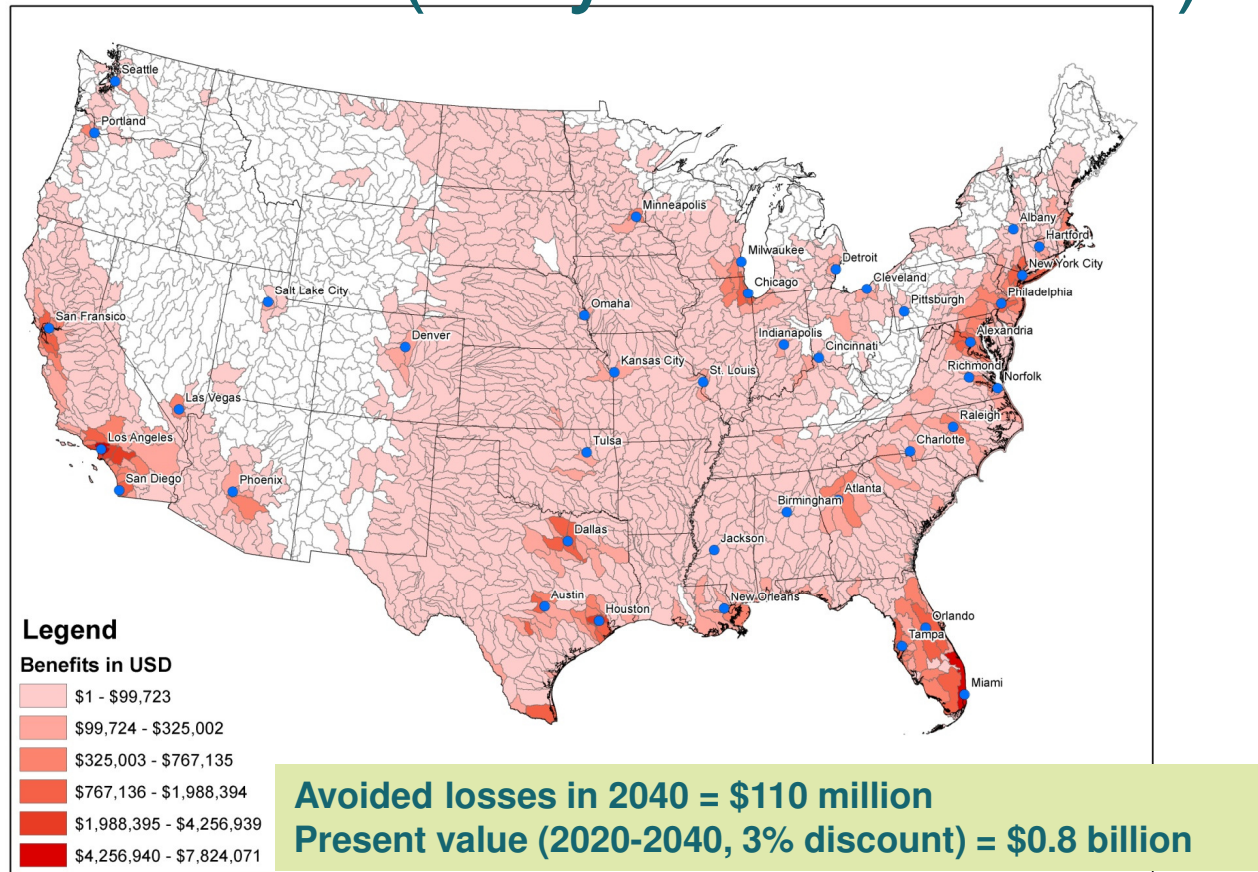
- Independent variables:
 - Development forecast (new development, redevelopment) as fraction of current development
 - Rainfall depths of 100-year storm
 - Average annual rainfall
- Dependent / predicted variables
 - Annual avoided losses as a fraction of total assets at risk



Losses Avoided (5-year threshold)



Losses Avoided (10-year threshold)



Validation Tests

- Diagnostic case studies, not calibration
- Stream gage approach vs. hydrologic modeling
- Zero-damage threshold
- NED terrain vs. LiDAR terrain
- GBS vs. user-defined facilities (UDF)



Conclusions

- When applied watershed wide, GI is effective at reducing
 - Peak flows for large events
 - Flood elevations
 - Flood losses
- Benefits can be quantified by the AALA



Questions

Thank you! For more information contact:

Leo Kreymborg (Atkins) leo.kreymborg@atkinsglobal.com

Dan Medina (Atkins) daniel.medina@atkinsglobal.com

Lisa Hair (EPA) hair.lisa@epa.gov